Phytoestrogens

General Information

Phytoestrogens are naturally occurring chemical constituents of certain plants that have estrogenic, and in some cases, antiestrogenic or antiandrogenic activity in animals and humans. Isoflavones and lignans are two major groups of phytoestrogens found in the human diet.

Isoflavones include daidzein, genistein, O-desmethylangolensin, equol, and others. Plant sources of isoflavones include legumes, such as soybeans and soy-based products. Formononectin and biochanin A are methylated isoflavones found in clovers and are metabolized to daidzein and genistein. Daidzein is further metabolized to O-desmethylangolensin by the body and to equol by intestinal bacteria.

Lignans include matairesinol, secoisolariciresinol, enterolactone, enterodiol, and others. Sources for lignans include whole grains, flax, and some fruits and vegetables. Matairesinol is metabolized to enterolactone. Enterodiol may be metabolized from secoisolariciresinol or interconverted with enterolactone.

Naringenin (precursor to genistein) and hesperetin are flavinoids found in higher amounts in citrus fruits. Resveratrol and *trans*-resveratrol are phytoestrogens present in grape skins and wine.

Diet is the primary source of phytoestrogens. They are ingested in their natural beta-glycosidic forms, which are hydrolyzed to their aglycones in the intestine, absorbed, and then glucuronidated in the intestinal wall. The major circulating forms of the isoflavones are actually the glucuronidated metabolites (Setchell et al., 2001), and glucuronidated forms also predominate in the urine (Adlercreutz et al., 1995*b*).

Generally, phytoestrogens are much less potent than the endogenously produced estrogens, but phtyoestrogens can be present in much greater quantities. Phytoestrogens have not been found to be acutely toxic in large-dose animal testing but have caused reduced reproductive capability in animals at chronic dietary doses. A few animal studies have suggested that phytoestrogens alter the fetal hormonal environment when present during gestation. Some actions of phytoestrogens are thought to occur through pathways other than interaction with estrogen receptors (Adlercreutz et al., 1995*a*; Dixon and Ferreira, 2002). In vitro, the various phytoestrogens can either inhibit or promote cancer-cell growth. Isoflavones are also considered antioxidants and have been studied for their effects on atherogenic blood lipids. Many of the different phytoestrogens have been tested for mutagenic activity in vitro and do not appear to be mutagenic, but studies assessing the carcinogenicity of phytoestrogens have not been performed.

Comparisons of Western diets with Japanese diets, which include higher intakes in Japanese women of soy-based foods, suggest that the higher isoflavone intake may account for the lower incidence of menopausal symptoms, such as hot flashes and osteoporosis. Hormone-dependent cancers of the breast and prostate also are lower in Japan than in other developed countries. In some observational studies, it was found that cancer incidence varied inversely with dietary phytoestrogen intake. However, genetic differences may account for some population differences. In addition, many other non-phytoestrogen flavinoid chemicals and vitamins present in plant foods that were not measured in these studies may also contribute to health outcomes. The effects of diets containing phytoestrogens on the incidence of breast and prostate cancer have primarily been studied in case-control designs and vary in outcome but with some suggestion of a protective benefit (Knowles et al., 2000; den Tonkelaar et al., 2001; Stattin et al., 2002; Ingram et al., 1997; Murkies et al., 2000). Potential anticancer benefits of phytoestrogens have previously been summarized by Adlercreutz et al. (1995*a*). Ingestion of isoflavones by people has shown varying effects on menstrual cycle, sex-hormone protein binding, pituitary responses, and bone density, depending on dose, type of phytoestrogen used, hormonal state of the subjects, and design of the studies (see, for example, Teede et al., 2001; Murkies et al., 2000; Xu et al., 2000; Hodgert et al., 2000; Safe et al., 2001; Nicholls et al., 2002; Kotsopoulos et al., 2000; Cassidy et al., 1994; Adlercreutz et al., 1995*a*; Kim et al., 2002).

Interpreting Urine Phytoestrogen Levels Reported in the Tables

Urine levels of phytoestrogens were measured in a subsample of NHANES participants aged 6 years and older. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. These phytoestrogen measurements

represent the first general examination of the U.S. population. Smaller studies have shown much higher levels of isoflavones in Japanese men and women than levels found in this NHANES 1999-2000 subsample, primarily because of a diet higher in soy products and lower in whole grains and cereals. Japanese women consuming approximately 16 and 30 mg/day of daidzein, equol, and genistein excreted approximately 3,000-5,000 µg/L of each isoflavone in their urine (Arai et al., 2000). Intake of 60 grams/day of soy powder by female subjects (n = 29) over a three-month period increased urinary levels of genistein, daidzein, and equol more than 13-fold over the baseline (unsupplemented) concentrations of 322, 42, 224, and 114 µg/L for enterolactone, equol, daidzein, and genistein, respectively (Albertazzi et al., 1999). The relation between the dose and urinary excretion is linear for many of the phytoestrogens studied, except for equol (Karr et al., 1997; Slavin et al., 1998; Lampe et al., 1999). Because excretory half-lives are reported to be in the range of 3-10 hours (Lu et al., 1995; Setchell et al., 2001), urinary concentrations reflect recent consumption. Urinary phytoestrogens have been measured to verify intake for several case-control studies. Levels in those control groups (varying with the base diet and population studied) were also much lower than levels in people consuming Japanese or high phytoestrogen diets although they were similar to or slightly higher than levels reported here.

In this NHANES 1999-2000 subsample, enterolactone showed the highest concentrations of any of the phytoestrogens measured, a finding which is consistent with a general U.S. diet that is higher in whole grains or cereals than in soybean sources of phytoestrogens. Geometric mean levels of the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. Urinary enterodiol and enterolactone levels were slightly higher for non-Hispanic whites than for Mexican Americans. Non-Hispanic blacks had lower enterodiol levels than non-Hispanic whites. Levels of the lignans have been previously reported to differ by race, with white females having higher concentrations than either Latina or African-American women (Horn-Ross et al., 1997). It is unknown whether these differences in race/ethnicity represent differences in exposure or metabolism.

Adjusted geometric mean genistein concentrations were higher in Mexican Americans than in non-Hispanic blacks. Mexican Americans had lower excretions of O-desmethylangolensin than either non-Hispanic whites or non-Hispanic blacks. There were no differences by race/ethnicity, gender, or age grouping for the excretion of the isoflavone, daidzein. Equol has more potent estrogen activity than its parent, daidzein. Higher urinary concentrations of equol were seen in non-Hispanic whites than in non-Hispanic blacks or Mexican Americans. Some studies have described excreters and nonexcreters of equol. Equol excretion may possibly depend on diet and the type of intestinal flora present (Hutchins et al., 1995; Karr et al., 1997; Setchell et al., 2001). No bimodality was apparent in the distribution of either equol concentrations or the equol/daidzein ratio in this NHANES subsample.

Finding a measurable amount of one or more of the phytoestrogens in urine does not mean that the level of one or more of these causes an adverse health effect. Whether the concentrations of the phytoestrogens reported here is a cause for health concern is not yet known; more research is needed. Measuring phytoestrogens at these levels in urine is possible because of advances in analytical chemistry. These levels provide physicians with reference levels so that they can determine whether people have been exposed to higher levels of phytoestrogens than to levels found in the general population. These data will also help scientists plan and conduct research on exposure and health effects.

Table 118. Phytoestrogens

Phytoestrogen	CAS number
Daidzein	486-66-8
Enterodiol	80226-00-2
Enterolactone	78473-71-9
Equol	531-95-3
Genistein	446-72-0
O-Desmethylangolensin	21255-69-6

Table 119. Daidzein

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	75.1 (64.7-87.1)	11.1 (9.30-12.8)	24.4 (22.1-29.2)	69.7 (59.8-78.7)	229 (183-299)	538 (462-710)	1310 (980-1580)	2554
Age group								
6-11 years	90.5 (70.8-116)	13.9 (9.41-21.9)	30.1 (22.9-39.7)	98.4 (71.3-139)	261 (194-375)	505 (437-765)	1130 (558-1770)	330
12-19 years	123 (98.8-154)	19.5 (16.8-26.2)	44.1 (35.8-55.1)	123 (92.9-160)	325 (264-407)	776 (483-1260)	1440 (964-2050)	753
20 years and older	67.6 (56.4-80.9)	9.89 (7.82-11.7)	22.4 (19.5-26.9)	60.9 (51.8-71.7)	215 (154-262)	518 (432-702)	1320 (838-1580)	1471
Gender								
Males	88.9 (76.1-104)	13.7 (11.5-17.6)	30.1 (24.6-37.9)	80.6 (70.8-101)	262 (217-328)	573 (510-935)	1540 (980-2080)	1220
Females	64.1 (51.9-79.2)	9.42 (7.69-11.6)	20.5 (17.9-26.9)	57.8 (46.8-72.1)	199 (142-259)	476 (389-722)	1220 (557-1530)	1334
Race/ethnicity								
Mexican Americans	79.0 (66.8-93.3)	11.2 (8.96-13.4)	23.4 (20.4-26.7)	66.7 (52.4-82.1)	249 (201-341)	800 (585-968)	1270 (978-2260)	817
Non-Hispanic blacks	91.9 (72.0-117)	13.6 (10.6-17.2)	29.6 (23.3-39.5)	101 (81.6-139)	286 (233-368)	545 (462-640)	1190 (756-1700)	607
Non-Hispanic whites	74.3 (63.7-86.6)	11.2 (9.30-13.9)	24.8 (22.2-29.8)	65.9 (57.5-75.0)	216 (157-287)	510 (432-772)	1360 (945-1740)	916

Table 120. Daidzein (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	68.5 (58.9-79.6)	10.5 (8.90-12.2)	23.2 (19.9-27.6)	65.1 (54.9-78.3)	204 (163-240)	555 (478-624)	944 (807-1260)	2554
Age group								
6-11 years	92.6 (73.6-116)	16.2 (11.1-22.7)	30.1 (25.3-49.2)	92.9 (67.9-118)	251 (158-319)	529 (359-838)	1030 (677-2150)	330
12-19 years	83.1 (63.7-108)	12.2 (8.18-18.6)	28.5 (22.6-36.4)	83.9 (56.0-113)	207 (162-304)	628 (386-944)	1000 (726-1530)	753
20 years and older	63.8 (53.7-75.8)	9.71 (7.86-11.8)	21.2 (18.0-26.3)	59.3 (50.2-72.4)	194 (150-235)	554 (468-624)	908 (714-1290)	1471
Gender								
Males	69.7 (58.6-82.8)	11.2 (8.91-13.2)	25.0 (19.7-28.0)	70.2 (54.8-82.5)	197 (158-247)	620 (497-807)	1050 (836-1400)	1220
Females	67.4 (55.4-82.1)	9.92 (8.06-13.0)	22.4 (18.4-29.9)	61.4 (51.9-79.9)	207 (155-249)	495 (372-624)	838 (610-1410)	1334
Race/ethnicity								
Mexican Americans	72.5 (62.6-83.9)	9.73 (8.47-11.7)	20.4 (17.3-25.3)	64.2 (47.1-91.1)	243 (195-303)	674 (492-944)	1360 (885-2370)	817
Non-Hispanic blacks	59.1 (47.3-73.8)	7.38 (5.36-10.7)	21.3 (15.4-29.6)	66.9 (52.1-86.1)	171 (129-216)	377 (291-562)	797 (552-1020)	607
Non-Hispanic whites	72.8 (62.5-84.7)	12.1 (10.4-15.1)	26.0 (21.6-30.3)	67.5 (58.0-79.6)	207 (162-249)	555 (464-628)	908 (701-1410)	916

Table 121. Enterodiol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	26.6 (22.8-31.1)	2.94 (<LOD-4.52)	11.8 (9.50-14.5)	34.0 (29.9-37.9)	78.7 (67.0-90.9)	165 (138-196)	266 (229-288)	2527
Age group								
6-11 years	26.5 (19.8-35.4)	3.92 (<LOD-6.85)	13.8 (7.55-18.6)	29.4 (21.5-42.2)	77.6 (51.7-91.8)	193 (103-276)	276 (142-375)	327
12-19 years	29.8 (24.1-36.7)	4.18 (2.46-6.94)	14.0 (9.86-21.1)	33.9 (29.0-40.7)	83.9 (61.6-101)	166 (119-219)	247 (170-337)	744
20 years and older	26.1 (22.1-30.8)	2.60 (<LOD-4.47)	11.1 (8.59-14.0)	34.3 (30.0-38.5)	78.2 (67.0-89.9)	160 (135-195)	261 (219-288)	1456
Gender								
Males	25.3 (21.0-30.4)	2.92 (<LOD-4.51)	11.4 (7.70-15.2)	33.0 (28.4-37.3)	72.6 (58.2-87.7)	149 (110-215)	258 (175-278)	1206
Females	27.9 (23.3-33.5)	3.13 (<LOD-5.52)	12.0 (9.99-15.3)	36.0 (29.4-40.5)	84.4 (69.9-98.8)	174 (142-219)	279 (229-335)	1321
Race/ethnicity								
Mexican Americans	21.7 (18.4-25.6)	< LOD	9.36 (7.43-11.5)	28.0 (23.7-34.9)	70.4 (60.8-78.8)	143 (120-169)	213 (168-282)	791
Non-Hispanic blacks	25.8 (21.7-30.8)	4.33 (2.46-5.97)	11.5 (9.97-14.5)	31.2 (24.4-36.5)	66.0 (50.6-84.4)	157 (116-219)	260 (172-348)	608
Non-Hispanic whites	29.2 (24.5-34.8)	3.53 (1.80-5.38)	13.2 (9.64-17.1)	37.5 (31.7-43.5)	85.8 (71.1-97.5)	171 (138-228)	270 (226-307)	914

< LOD means less than the limit of detection, which is 0.8 µg/L.

Table 122. Enterodiol (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	24.2 (21.0-28.0)	2.68 (2.05-3.78)	10.9 (9.06-13.1)	29.9 (26.3-33.6)	70.5 (60.2-81.6)	146 (124-177)	240 (197-321)	2527
Age group								
6-11 years	27.0 (21.1-34.6)	3.15 (1.46-7.29)	13.6 (9.13-15.3)	33.7 (23.1-42.2)	62.7 (47.9-91.1)	150 (83.2-260)	290 (150-411)	327
12-19 years	20.1 (17.0-23.7)	2.36 (1.58-3.94)	9.69 (7.70-12.3)	24.1 (20.8-28.6)	55.0 (43.0-71.4)	99.5 (91.3-121)	158 (106-184)	744
20 years and older	24.7 (20.9-29.0)	2.65 (1.92-3.90)	10.9 (8.47-13.4)	30.6 (26.3-34.5)	72.7 (62.5-84.5)	155 (129-184)	240 (199-344)	1456
Gender								
Males	19.8 (16.5-23.8)	2.34 (1.24-3.01)	8.65 (6.66-11.2)	25.4 (21.4-30.0)	55.1 (47.6-63.7)	121 (96.4-167)	197 (151-260)	1206
Females	29.3 (24.8-34.7)	3.56 (2.05-5.68)	13.5 (10.5-15.3)	34.9 (29.5-41.8)	85.2 (72.7-98.3)	164 (132-216)	321 (220-371)	1321
Race/ethnicity								
Mexican Americans	19.6 (16.5-23.3)	< LOD	8.69 (6.35-11.1)	23.5 (20.4-27.7)	59.6 (50.0-76.3)	134 (114-154)	193 (154-230)	791
Non-Hispanic blacks	16.6 (14.0-19.6)	2.40 (.994-3.46)	6.91 (5.35-9.31)	18.8 (14.3-23.0)	47.3 (37.7-55.8)	113 (88.0-143)	165 (134-237)	608
Non-Hispanic whites	28.6 (24.4-33.5)	3.33 (2.48-5.91)	13.5 (10.9-15.6)	33.8 (29.5-38.6)	75.8 (64.1-91.3)	162 (128-203)	252 (199-370)	914

< LOD means less than the limit of detection (see previous table).

Table 123. Enterolactone

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	239 (204-281)	25.4 (18.8-38.9)	107 (83.8-126)	315 (248-377)	726 (616-850)	1970 (1490-2330)	2790 (2480-3070)	2548
Age group								
6-11 years	308 (232-408)	46.5 (19.1-117)	161 (114-211)	353 (283-434)	721 (596-1250)	1730 (1250-2440)	2840 (1730-3350)	331
12-19 years	250 (201-311)	29.6 (13.7-55.3)	122 (84.3-162)	317 (254-380)	670 (486-840)	1760 (984-2480)	2900 (1900-4420)	746
20 years and older	230 (194-273)	23.3 (16.7-37.5)	98.4 (76.5-118)	310 (239-381)	728 (608-879)	1980 (1530-2330)	2790 (2530-3540)	1471
Gender								
Males	254 (212-305)	24.0 (17.5-35.7)	110 (79.0-137)	351 (266-417)	778 (636-959)	1980 (1610-2340)	2730 (2430-3440)	1219
Females	226 (181-283)	31.5 (13.7-51.0)	105 (77.1-129)	287 (236-338)	684 (539-824)	1880 (1240-2420)	2830 (2280-3880)	1329
Race/ethnicity								
Mexican Americans	212 (164-274)	30.7 (10.4-43.9)	99.6 (73.3-123)	281 (231-332)	631 (531-740)	1650 (896-2260)	2690 (2120-3720)	813
Non-Hispanic blacks	262 (208-328)	31.8 (12.3-57.8)	132 (104-163)	360 (312-417)	759 (657-861)	1710 (1150-2290)	2500 (1980-3280)	605
Non-Hispanic whites	247 (200-304)	24.1 (16.9-43.8)	105 (78.0-132)	317 (242-400)	751 (599-956)	2040 (1400-2530)	2950 (2530-3640)	916

Table 124. Enterolactone (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	218 (186-257)	21.4 (14.0-31.2)	91.2 (76.2-107)	284 (250-329)	733 (617-867)	1570 (1280-1850)	2240 (1880-2770)	2548
Age group								
6-11 years	315 (246-403)	69.3 (41.3-91.9)	146 (103-208)	384 (278-431)	703 (564-1020)	1570 (1020-2010)	2100 (1580-3410)	331
12-19 years	169 (138-206)	17.9 (11.9-29.3)	80.5 (64.0-101)	208 (172-254)	484 (394-596)	1150 (815-1540)	1850 (1310-2320)	746
20 years and older	217 (181-261)	18.6 (11.1-28.1)	85.8 (72.1-105)	288 (249-350)	785 (653-923)	1610 (1350-1890)	2300 (1930-2950)	1471
Gender								
Males	199 (168-236)	18.7 (13.3-27.4)	82.2 (69.2-104)	263 (234-308)	664 (531-810)	1380 (1180-1780)	2010 (1790-2320)	1219
Females	238 (191-297)	27.9 (13.1-44.2)	101 (75.4-131)	302 (254-381)	819 (653-973)	1690 (1420-1990)	2550 (1930-3410)	1329
Race/ethnicity								
Mexican Americans	194 (154-245)	21.2 (10.7-33.2)	92.4 (64.5-125)	254 (211-305)	605 (478-738)	1340 (913-1860)	2100 (1550-2800)	813
Non-Hispanic blacks	168 (132-214)	25.4 (7.33-40.8)	87.4 (63.5-112)	212 (183-253)	539 (424-664)	1130 (937-1440)	1590 (1290-1970)	605
Non-Hispanic whites	241 (195-300)	20.3 (13.1-36.4)	96.0 (74.6-132)	323 (270-393)	828 (653-1040)	1780 (1410-2020)	2480 (1980-3330)	916

Table 125. Equol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	8.37 (7.03-9.97)	< LOD	< LOD	8.02 (5.98-10.1)	17.2 (14.5-20.5)	35.0 (29.6-39.7)	53.5 (41.6-71.7)	2182
Age group								
6-11 years	10.5 (7.77-14.1)	< LOD	4.52 (<LOD-6.61)	11.2 (6.11-17.5)	24.9 (17.3-29.5)	34.4 (28.6-56.1)	54.8 (31.0-76.3)	272
12-19 years	10.9 (8.54-13.9)	< LOD	4.53 (<LOD-6.96)	10.7 (8.28-13.8)	22.0 (16.2-34.8)	42.9 (35.4-68.7)	71.6 (48.2-147)	657
20 years and older	7.79 (6.59-9.22)	< LOD	< LOD	7.43 (5.52-9.17)	16.0 (12.9-18.7)	33.1 (26.4-37.7)	52.2 (37.5-75.3)	1253
Gender								
Males	9.15 (7.33-11.4)	< LOD	3.08 (<LOD-4.64)	8.44 (6.11-11.9)	19.0 (15.9-24.0)	35.6 (30.2-48.7)	71.3 (45.2-112)	1042
Females	7.70 (6.54-9.07)	< LOD	< LOD	7.57 (5.64-9.28)	15.6 (12.6-19.0)	33.5 (26.4-37.7)	48.2 (37.5-58.7)	1140
Race/ethnicity								
Mexican Americans	5.24 (4.81-5.71)	< LOD	< LOD	4.49 (3.77-5.11)	9.44 (7.90-10.5)	18.5 (13.7-23.1)	30.9 (22.3-47.6)	726
Non-Hispanic blacks	6.73 (5.46-8.30)	< LOD	< LOD	6.24 (4.09-9.95)	15.1 (12.7-17.6)	27.6 (21.1-32.7)	36.4 (30.2-47.6)	514
Non-Hispanic whites	9.26 (7.47-11.5)	< LOD	3.63 (<LOD-5.04)	8.95 (6.43-12.3)	19.0 (15.7-23.7)	36.1 (30.1-45.4)	56.1 (45.2-75.3)	757

< LOD means less than the limit of detection, which is 3.0 µg/L.

Table 126. Equol (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	7.70 (6.51-9.12)	< LOD	< LOD	7.96 (6.42-9.73)	16.2 (12.5-19.5)	30.6 (26.1-37.1)	50.3 (41.2-69.9)	2182
Age group								
6-11 years	10.3 (7.71-13.7)	< LOD	4.38 (2.87-7.94)	11.4 (7.64-16.3)	22.6 (12.7-30.6)	31.5 (25.5-48.1)	47.8 (32.7-150)	272
12-19 years	7.61 (6.11-9.47)	< LOD	3.55 (2.86-4.82)	8.02 (6.24-9.87)	13.9 (11.4-20.4)	27.3 (21.0-37.3)	47.4 (28.2-79.0)	657
20 years and older	7.45 (6.29-8.82)	< LOD	< LOD	7.63 (5.99-9.54)	15.3 (12.3-18.3)	30.8 (25.0-37.2)	51.6 (41.1-71.8)	1253
Gender								
Males	7.01 (5.75-8.54)	< LOD	2.87 (2.02-3.78)	7.31 (5.45-9.18)	13.8 (11.6-17.6)	29.3 (21.4-41.8)	54.1 (35.8-81.0)	1042
Females	8.41 (7.13-9.93)	< LOD	< LOD	8.65 (7.08-10.3)	17.4 (14.0-21.5)	31.6 (26.3-37.5)	46.0 (38.8-57.0)	1140
Race/ethnicity								
Mexican Americans	4.89 (4.34-5.50)	< LOD	< LOD	4.73 (3.85-5.46)	8.83 (7.99-10.1)	22.3 (16.3-27.7)	36.8 (25.3-58.1)	726
Non-Hispanic blacks	4.36 (3.57-5.32)	< LOD	< LOD	4.57 (3.10-6.17)	10.2 (7.95-12.0)	17.1 (14.8-19.8)	25.6 (19.6-32.0)	514
Non-Hispanic whites	9.13 (7.41-11.3)	< LOD	4.24 (2.99-5.73)	9.38 (7.31-11.7)	18.0 (14.0-22.6)	35.1 (28.8-41.8)	56.5 (43.8-78.5)	757

< LOD means less than the limit of detection (see previous table).

Table 127. Genistein

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	24.4 (20.5-29.1)	1.91 (.670-3.05)	8.67 (7.24-10.3)	27.0 (22.9-31.6)	93.6 (74.4-119)	284 (229-353)	562 (413-734)	2557
Age group								
6-11 years	27.6 (21.4-35.7)	3.30 (1.26-6.81)	8.15 (6.81-10.6)	31.9 (18.5-39.5)	104 (67.6-151)	218 (151-318)	376 (234-725)	331
12-19 years	43.7 (35.0-54.4)	6.04 (3.65-9.60)	17.2 (12.8-21.7)	45.4 (34.7-59.5)	137 (93.7-184)	319 (257-446)	547 (363-753)	754
20 years and older	21.9 (17.6-27.1)	1.26 (<LOD-2.80)	8.09 (5.94-9.50)	24.0 (21.1-28.7)	86.2 (61.6-119)	284 (217-362)	566 (393-797)	1472
Gender								
Males	29.8 (24.2-36.6)	2.85 (1.56-4.28)	10.1 (8.12-12.1)	31.8 (27.1-36.9)	108 (80.1-151)	335 (256-440)	709 (443-981)	1222
Females	20.3 (16.4-25.1)	1.10 (<LOD-2.64)	7.39 (5.11-9.46)	23.1 (18.7-28.4)	84.7 (55.6-113)	235 (193-303)	427 (339-674)	1335
Race/ethnicity								
Mexican Americans	31.1 (26.3-36.8)	3.35 (2.01-4.32)	9.97 (8.51-12.3)	30.0 (25.1-37.5)	117 (95.8-153)	328 (247-494)	570 (479-893)	819
Non-Hispanic blacks	26.7 (20.1-35.3)	1.70 (<LOD-4.80)	10.4 (6.30-14.9)	32.8 (26.3-39.4)	103 (77.3-143)	252 (209-367)	495 (346-898)	608
Non-Hispanic whites	23.6 (19.2-29.0)	1.69 (.500-3.10)	8.55 (6.89-10.3)	25.3 (22.0-31.6)	90.4 (66.8-124)	288 (217-371)	525 (355-797)	916

< LOD means less than the limit of detection, which is 0.3 µg/L.

Table 128. Genistein (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	22.3 (18.7-26.5)	1.99 (1.13-3.16)	7.64 (6.39-9.01)	23.8 (19.3-28.4)	84.7 (69.1-103)	222 (190-274)	380 (323-524)	2557
Age group								
6-11 years	28.3 (21.8-36.6)	3.66 (1.86-6.91)	10.4 (7.44-12.8)	27.8 (16.8-40.7)	94.3 (65.6-145)	206 (154-286)	490 (255-895)	331
12-19 years	29.4 (23.1-37.4)	4.07 (2.45-6.26)	11.2 (7.51-15.3)	32.0 (23.8-41.6)	83.2 (65.7-101)	181 (134-264)	336 (199-737)	754
20 years and older	20.6 (16.8-25.3)	1.62 (.724-2.98)	6.85 (5.48-8.58)	21.6 (17.3-26.9)	83.1 (65.4-105)	234 (190-287)	381 (325-562)	1472
Gender								
Males	23.3 (18.6-29.3)	2.28 (1.34-4.02)	7.75 (6.19-9.50)	23.8 (18.3-31.2)	86.1 (67.6-114)	234 (190-323)	523 (317-889)	1222
Females	21.3 (17.6-25.9)	1.90 (1.00-3.00)	7.56 (5.66-9.68)	22.9 (17.4-29.5)	83.1 (62.7-104)	209 (161-282)	357 (273-435)	1335
Race/ethnicity								
Mexican Americans	28.4 (24.0-33.7)	3.14 (1.93-4.26)	8.12 (5.99-10.1)	27.9 (21.8-36.3)	109 (91.5-137)	257 (215-344)	562 (323-844)	819
Non-Hispanic blacks	17.1 (13.2-22.2)	1.32 (.329-3.68)	6.81 (5.01-8.69)	19.5 (15.7-25.0)	59.0 (43.1-93.0)	178 (130-245)	299 (222-427)	608
Non-Hispanic whites	23.1 (18.9-28.4)	2.00 (1.00-3.77)	8.11 (6.26-10.2)	24.8 (19.0-30.5)	86.1 (67.6-105)	232 (178-295)	381 (318-593)	916

Table 129. O-Desmethylangolensin

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	4.34 (3.55-5.32)	< LOD	.750 (.310-1.15)	4.88 (3.92-5.93)	22.7 (18.7-29.9)	100 (74.8-146)	217 (154-275)	2295
Age group								
6-11 years	5.33 (3.82-7.45)	< LOD	.920 (.400-2.42)	6.93 (3.93-11.6)	36.2 (20.3-45.0)	78.7 (45.8-176)	176 (74.8-264)	290
12-19 years	5.96 (4.09-8.68)	< LOD	1.23 (<LOD-2.58)	7.58 (5.37-12.2)	36.4 (24.3-51.8)	106 (74.1-140)	194 (123-228)	677
20 years and older	4.02 (3.25-4.97)	< LOD	.700 (<LOD-1.08)	4.40 (3.40-5.42)	19.4 (16.2-25.5)	101 (70.5-155)	228 (150-322)	1328
Gender								
Males	4.94 (3.92-6.21)	< LOD	.780 (<LOD-1.26)	5.62 (4.50-8.03)	28.4 (20.7-40.3)	121 (94.4-157)	234 (179-309)	1098
Females	3.85 (2.95-5.03)	< LOD	.690 (<LOD-1.18)	4.21 (3.02-5.51)	19.1 (14.1-25.5)	83.8 (56.6-149)	191 (93.1-272)	1197
Race/ethnicity								
Mexican Americans	2.24 (1.66-3.03)	< LOD	< LOD	1.99 (1.33-2.88)	19.7 (9.90-27.4)	96.6 (57.4-137)	190 (125-317)	742
Non-Hispanic blacks	5.63 (4.20-7.53)	< LOD	.870 (<LOD-2.05)	8.43 (5.47-11.3)	33.2 (22.5-51.8)	108 (88.8-149)	177 (133-242)	540
Non-Hispanic whites	4.48 (3.57-5.62)	< LOD	.790 (.480-1.23)	4.96 (3.56-6.55)	22.5 (17.7-31.9)	103 (70.5-155)	228 (150-281)	827

< LOD means less than the limit of detection, which is 0.2 µg/L.

Table 130. O-Desmethylangolensin (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	3.97 (3.19-4.95)	< LOD	.776 (.560-1.05)	4.42 (3.40-5.73)	21.5 (17.3-28.0)	90.3 (60.6-125)	165 (125-235)	2295
Age group								
6-11 years	5.67 (4.00-8.02)	< LOD	1.30 (.556-2.50)	6.73 (4.23-12.8)	28.8 (18.8-39.0)	79.8 (47.7-130)	179 (83.3-262)	290
12-19 years	4.08 (2.62-6.36)	< LOD	.734 (.230-1.85)	5.63 (3.20-9.74)	26.0 (16.9-38.1)	71.4 (47.6-100)	115 (77.7-223)	677
20 years and older	3.79 (3.05-4.71)	< LOD	.724 (.551-.971)	3.89 (2.91-5.34)	20.2 (13.9-25.8)	96.5 (57.6-140)	165 (125-270)	1328
Gender								
Males	3.92 (3.07-5.00)	< LOD	.720 (.359-1.16)	4.46 (3.29-6.02)	24.5 (16.9-33.4)	96.5 (62.4-123)	209 (131-262)	1098
Females	4.03 (3.06-5.29)	< LOD	.782 (.605-1.13)	4.17 (3.10-6.20)	19.8 (14.3-26.7)	83.3 (49.7-140)	155 (90.3-220)	1197
Race/ethnicity								
Mexican Americans	2.03 (1.52-2.72)	< LOD	< LOD	1.76 (1.13-2.67)	13.9 (11.1-25.2)	67.3 (54.0-95.5)	136 (97.9-218)	742
Non-Hispanic blacks	3.58 (2.67-4.81)	< LOD	.612 (.165-1.24)	5.20 (3.37-7.33)	23.4 (17.3-32.1)	67.1 (51.7-79.7)	115 (79.2-308)	540
Non-Hispanic whites	4.40 (3.45-5.60)	< LOD	.884 (.645-1.18)	4.65 (3.40-6.35)	22.2 (17.3-31.5)	102 (57.5-148)	170 (126-235)	827

< LOD means less than the limit of detection (see previous table).